

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE (DD-MM-YYYY)

2. REPORT TYPE
Technical Papers

3. DATES COVERED (From - To)

4. TITLE AND SUBTITLE

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER
4847

5e. TASK NUMBER
0159

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

8. PERFORMING ORGANIZATION
REPORT

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

10. SPONSOR/MONITOR'S
ACRONYM(S)

11. SPONSOR/MONITOR'S
NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

20021212 107

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

a. REPORT

Unclassified

b. ABSTRACT

Unclassified

c. THIS PAGE

Unclassified

17. LIMITATION
OF ABSTRACT

A

18. NUMBER
OF PAGES

19a. NAME OF RESPONSIBLE
PERSON

Leilani Richardson

19b. TELEPHONE NUMBER
(include area code)

(661) 275-5015

3 Spoke

42479158

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

01 Oct 2001

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-AB-2001-196**
Frank Mead, Jr., Bill Larson, Wayne Kalliomaa, "A Status Report of the X-50LR Program – A Laser
Propulsion Program" (Abstract only)

33rd AIAA Plasmadynamics & Lasers Conference
(Maui, HI, 20-23 May 2002) (Deadline: 15 October 2001)

(Statement A)

1. This request has been reviewed by the Foreign Disclosure Office for: a.) appropriateness of distribution statement,
b.) military/national critical technology, c.) export controls or distribution restrictions,
d.) appropriateness for release to a foreign nation, and e.) technical sensitivity and/or economic sensitivity.

Comments: _____

Signature _____ Date _____

2. This request has been reviewed by the Public Affairs Office for: a.) appropriateness for public release
and/or b) possible higher headquarters review.

Comments: _____

Signature _____ Date _____

3. This request has been reviewed by the STINFO for: a.) changes if approved as amended,
b) appropriateness of references, if applicable; and c.) format and completion of meeting clearance form if required

Comments: _____

Signature _____ Date _____

4. This request has been reviewed by PR for: a.) technical accuracy, b.) appropriateness for audience, c.)
appropriateness of distribution statement, d.) technical sensitivity and economic sensitivity, e.) military/
national critical technology, and f.) data rights and patentability

Comments: _____

APPROVED/APPROVED AS AMENDED/DISAPPROVED

PHILIP A. KESSEL Date
Technical Advisor
Space and Missile Propulsion Division

A STATUS REPORT OF THE X-50LR PROGRAM — A LASER PROPULSION PROGRAM

Please add a
dash or a colon
after "X-50LR
Program"

Franklin B. Mead, Jr., C. William Larson, and Wayne M. Kalliomaa
Propulsion Directorate
Air Force Research Laboratory
Edwards AFB CA 93524-7680

Abstract

*use make
: "a" into
an"*

In 1996, the Air Force Research Laboratory's Propulsion Division at Edwards AFB initiated a program that had as its main objective to launch a laser-propelled vehicle into a suborbital trajectory within a period of 5 years in order to demonstrate the concept and its attractive features. The concept was to be a nanosatellite in which the laser propulsion engine and satellite hardware were intimately shared. This concept was based upon a 1989 design developed at Rensselaer Polytechnic Institute under a Space Defense Initiative Office (SDIO) laser propulsion program.¹ The forebody aeroshell had been designed to act as an external compression surface (i.e., the airbreathing engine inlet). The afterbody served a dual function as a primary receptive optic (parabolic mirror) for the laser beam and as an external expansion surface (plug nozzle). The primary thrust structure was the centrally located annular shroud. The shroud provided air through inlets and acts as a² energy absorption chamber for plasma formation. In the rocket mode, the air inlets were closed, and the afterbody and shroud combined to form the rocket thrust chamber and plug ("aerospike-type") nozzle. The full-scale vehicle was 1.4 meters in diameter with a dry mass of 120 kg. Fully fueled, this vehicle would have an initial mass of about 240 kg (i.e., a mass fraction of 0.5), and would be launched into orbit with a 100 megawatt-class infrared ground-based laser (GBL). This laser propelled vehicle would be a single-stage-to-orbit (i.e., airbreathing only to M=5 and 30 km; a laser thermal rocket, using liquid propellants, at higher altitudes and in space) using a combined-cycle pulsed detonation engine. Once in space, the Lightcraft was to use its one meter diameter optical system to provide, for example, Earth surveys from low Earth orbit (LEO) with ~~from~~ 8 to 15 cm resolution in the visible light frequencies. Such a device was simple, reliable, safe, environmentally clean, and could have a very high all azimuth on demand launch rate.

*use delete
- "from"*

The Lightcraft Technology Demonstration (LTD) program, initiated in 1996, was planned in three phases. Phase I, Lightcraft Concept Demonstration, was to demonstrate the feasibility of the basic concept. This phase ended successfully in December 1998. Under Phase I, performance was measured with pendulum impulse and piezoelectric thrust stands, shadowgraph studies were conducted, beam propagation energy measurements were made to 90 m, a pointing and tracking system was developed and demonstrated on horizontal wire-guided flights outdoors to 122 m, and outdoor vertical free-flights approaching 30 m were successfully conducted.^{1,2,3,4} Low Mach number wind tunnel tests were also accomplished with a 23-cm diameter model.⁵ The basic conclusion of all this work was that the feasibility and basic physics of the Lightcraft concept had been adequately demonstrated, and that a much larger, 100 kW class laser would be required to completely accomplish Phase II.

Phase II, Lightcraft Vertical Launches to Extreme Altitudes, was initiated in January¹⁹ 99, and was a five-year effort designed to extend Lightcraft flights in sounding rocket trajectories to

Please delete
the ampersand

Suggest adding
"19" → "1999"

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

30 km with a 100 kW CO₂ laser. The first step of the Phase II vertical flight test program was to extend Lightcraft vertical free-flights to significantly higher altitudes in the range of 150 to 300 m using the 10 kW PLVTS laser.⁵ Tenth-scale laser-powered vehicles were used. With this size vehicle, laser flight tests were conducted at the High Energy Laser Systems Test Facility (HELSTF), White Sands Missile Range (WSMR), New Mexico, using the 10 kW, Pulsed Laser Vulnerability Test System (PLVTS), CO₂, electric discharge laser. The first composite, ceramic shroud components for the Lightcraft vehicle were fabricated, laboratory tested for performance, and flight tested. Performance details were previously presented comparing the composite material shroud with the all-aluminum vehicles which had been used to that point in the program.

In January 2001, a new program was initiated to scale-up the initial Phase II vehicle to a 50-cm focal diameter completely functional flight vehicle. This program is named the X-50LR for Experimental 50-centimeter Laser Rocket. It borrowed certain aspects of the previous LTD program, but forged a new "team" concept with ^{an}appropriately modified schedule and funding. The details of this new program and its progress will be discussed. The results of Laboratory and outdoor flight test ^{ing} will be presented, along with the most recent progress towards a 100 kW isotopic CO₂ pulsed electric laser.

can add
n "e"
use make
it into
esting

please add "an"
where indicated
(or)
make "schedule"
into "scheduling"
(without the "an")

References

1. Myrabo, L.N. et al., "Transatmospheric Laser Propulsion," Final Technical Report, Rensselaer Polytechnic Institute, prepared under Contract No. 2073803 for Lawrence Livermore National Laboratory and the SDIO Laser Propulsion Program, 30 Jun 89.
2. Myrabo, L.N., Messitt, D.G., & Mead, F.B., Jr., "Ground and Flight Tests of a Laser Propelled Vehicle," AIAA 98-1001, 36th Aerospace Sciences Meeting & Exhibit, Reno NV, 12-15 Jan 98.
3. Mead, F.B., Jr., Myrabo, L.N., & Messitt, D.G., "Flight and Ground Tests of a Laser-Boosted Vehicle," AIAA 98-3735, 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conf., Cleveland OH, 13-15 Jul 98.
4. Messitt, D.G., Myrabo, L.N., Mead, F.B., Jr., "Laser Initiated Blast Wave for Launch Vehicle Propulsion," AIAA 2000-3848, 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conf., Huntsville AL, 17-19 Jul 00.
5. Panetta, A.D., Negamatsu, H.T., Myrabo, L.N., Minucci, M.A.S., Mead, F.B., Jr., "Low Speed Wind Tunnel Testing of a Laser Propelled Vehicle," SAE International and AIAA 1999-01-5577, 1999 World Aviation Conf., San Francisco CA, 19-21 Oct 99.
5. Mead, F.B., Jr., Squires, S., Beirsto, C., & Thurston, M., "Flights of a Laser-Powered Lightcraft During Laser Beam Hand-off Experiments," AIAA 2000-3484, 36th AIAA/ASME/SAE/ASEE Joint Propulsion Conf., Huntsville AL, 16-19 Jul 00.
6. Mead, F.B., Jr. and Larson, C.W., "Laser Powered, Vertical Flight Experiments at the High Energy Laser System Test Facility," AIAA 2001-3661, 37th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, Salt Lake City UT, 8-11 Jul 01.